Claims

The following listing of claims will replace all prior versions, and listings, of claims in the present application:

1. (Previously Presented) A method of reducing an amount of carbon monoxide in a feed stream for a fuel cell, comprising:

introducing a hydrocarbon feed stream into a primary reactor and reacting the hydrocarbon feed stream in effective contact with a reforming catalyst forming primary reactor products containing hydrogen, carbon monoxide, carbon dioxide, and methane;

placing a high activity water gas shift catalyst system into a water gas shift converter, the high activity water gas shift catalyst system comprising a noble metal; a mixed metal oxide support consisting essentially of cerium oxide and zirconium oxide, wherein cerium oxide is present in an amount from about 58% to about 80% by weight of mixed metal oxide and zirconium oxide is present in amount from about 42% to about 20% by weight of mixed metal oxide, and optionally a support dopant; and about 0.1% to about 1.0% by weight of total catalyst of a promoter comprising alkali metals, or alkaline earth metals, or combinations thereof; and

introducing the primary reactor products into the water gas shift converter in effective contact with the high activity water gas shift catalyst system, and reacting the carbon monoxide and water to form carbon dioxide and hydrogen using a water gas shift reaction forming the feed stream for the fuel cell; and

introducing the feed stream into the fuel cell;

wherein the high activity water gas shift catalyst system converts at least 50% of the carbon monoxide in the primary reactor products into carbon dioxide and hydrogen by the water gas shift reaction over a temperature range from about 300°C to about 450°C.

2. (Original) The method of claim 1 wherein the noble metal is selected from platinum, palladium, mixtures of platinum and palladium, or mixtures of platinum and iridium.

3. (Original) The method of claim 1 wherein the noble metal is present in an amount of between about 1% to about 4% by weight of total catalyst.

4. (Previously Presented) The method of claim 1 wherein the promoter is selected from cesium, lithium, rubidium, potassium, magnesium, strontium, barium, calcium, or combinations thereof.

5-6. (Canceled)

7. (Previously Presented) The method of claim 1 wherein the support dopant is selected from lanthanum, praseodymium, neodymium, or combinations thereof.

8. (Previously Presented) The method of claim 1 wherein the support dopant is in the form of a metal oxide.

9. (Previously Presented) The method of claim 1 wherein the support dopant is present in an amount of between about 1 and about 5% by weight of mixed metal oxide.

10. (Original) The method of claim 1 wherein passing the process fuel gas through the water gas shift converter is performed at a temperature in the range of about 200°C to about 400°C.

11. (Original) The method of claim 1 wherein passing the process fuel gas through the water gas shift converter is performed at a temperature in the range of about 250°C to about 375°C.

12. (Previously Presented) A method of reducing an amount of carbon monoxide in a feed stream for a fuel cell, comprising:

introducing a hydrocarbon feed stream into a primary reactor and reacting the hydrocarbon feed stream in effective contact with a reforming catalyst forming primary reactor products containing hydrogen, carbon monoxide, carbon dioxide, and methane;

placing a high activity water gas shift catalyst system into a water gas shift converter, the high activity water gas shift catalyst system comprising a noble metal; a mixed metal oxide support of cerium oxide and zirconium oxide, wherein cerium oxide is present in an amount from about 20% to less than 58% by weight of mixed metal oxide and zirconium oxide is present in

amount from more than 42% to about 80% by weight of mixed metal oxide; and about 0.1% to about 1.0% by weight of total catalyst of a promoter comprising at least one metal selected from alkali metals, or alkaline earth metals; and

introducing the primary reactor products into the water gas shift converter in effective contact with the high activity water gas shift catalyst system, and reacting the carbon monoxide and water to form carbon dioxide and hydrogen using a water gas shift reaction forming the feed stream for the fuel cell; and

introducing the feed stream into the fuel cell;

wherein the high activity water gas shift catalyst system converts at least 50% of the carbon monoxide in the primary reactor products into carbon dioxide and hydrogen by the water gas shift reaction over a temperature range from about 300°C to about 450°C.

13. (Original) The method of claim 12 wherein the noble metal is selected from platinum, palladium, mixtures of platinum and palladium, or mixtures of platinum and iridium.

14. (Original) The method of claim 12 wherein the noble metal is present in an amount of between about 1% to about 4% by weight of total catalyst.

15. (Canceled)

16. (Previously Presented) The method of claim 12 wherein the promoter is selected from cesium, lithium, rubidium, potassium, magnesium, strontium, barium, calcium, or combinations thereof.

17. (Canceled)

18. (Original) The method of claim 12 wherein the mixed metal oxide support further comprises a support dopant.

19. (Original) The method of claim 18 wherein the support dopant is selected from lanthanum, praseodymium, neodymium, or combinations thereof.

20. (Original) The method of claim 18 wherein the support dopant is in the form of a metal oxide.

21. (Original) The method of claim 18 wherein the support dopant is present in an amount of between about 1 and about 5% by weight of mixed metal oxide.

22. (Original) The method of claim 12 wherein passing the process fuel gas through the water gas shift converter is performed at a temperature in the range of about 200°C to about 400°C.

23. (Original) The method of claim 12 wherein passing the process fuel gas through the water gas shift converter is performed at a temperature in the range of about 250°C to about 375°C.

24. (Previously Presented) A method of reducing an amount of carbon monoxide in a feed stream for a fuel cell, comprising:

introducing a hydrocarbon feed stream into a primary reactor and reacting the hydrocarbon feed stream in effective contact with a reforming catalyst forming primary reactor products containing hydrogen, carbon monoxide, carbon dioxide, and methane;

placing a high activity water gas shift catalyst system into a water gas shift converter, the high activity water gas shift catalyst system comprising a noble metal; a mixed metal oxide support consisting essentially of cerium oxide and lanthanum oxide~~:~~, and optionally a support dopant; and about 0.1% to about 1.0% by weight of total catalyst of a promoter comprising at least one metal selected from alkali metals, or alkaline earth metals; and

introducing the primary reactor products into the water gas shift converter in effective contact with the high activity water gas shift catalyst system, and reacting the carbon monoxide and water to form carbon dioxide and hydrogen using a water gas shift reaction forming the feed stream for the fuel cell; and

introducing the feed stream into the fuel cell;

wherein the high activity water gas shift catalyst system converts at least 40% of the carbon monoxide primary reactor products into carbon dioxide and hydrogen by the water gas shift reaction over a temperature range from about 400°C to about 575°C.

25. (Original) The method of claim 24 wherein the noble metal is selected from platinum, palladium, mixtures of platinum and palladium, or mixtures of platinum and iridium.

26. (Original) The method of claim 24 wherein the noble metal is present in an amount of between about 1% to about 4% by weight of total catalyst.

27. (Original) The method of claim 24 wherein cerium oxide is present in an amount from about 92% to about 20% by weight of mixed metal oxide and lanthanum oxide is present in amount from about 8% to about 80% by weight of mixed metal oxide.

28. (Canceled)

29. (Currently Amended) The method of claim ~~28~~ 24 wherein the promoter is selected from cesium, lithium, rubidium, potassium, magnesium, strontium, barium, calcium, or combinations thereof.

30. (Canceled)

31. (Original) The method of claim 24 wherein the support dopant is selected from praseodymium, neodymium, or combinations thereof.

32. (Original) The method of claim 24 wherein the support dopant is in the form of a metal oxide.

33. (Original) The method of claim 31 wherein the support dopant is present in an amount of between about 1 and about 5% by weight of mixed metal oxide.

34. (Original) The method of claim 24 wherein passing the process fuel gas through the water gas shift converter is performed at a temperature in the range of about 200°C to about 425°C.

35. (Original) The method of claim 24 wherein passing the process fuel gas through the water gas shift converter is performed at a temperature in the range of about 275°C to about 400°C.

36. (Currently Amended) A high activity water gas shift catalyst system for a fuel cell, in which there is a primary reactor with a reforming catalyst followed by a water gas shift converter with the high activity water gas shift catalyst system to provide a feed stream for the fuel cell, the high activity water gas shift catalyst system comprising:

a noble metal;

a mixed metal oxide support consisting essentially of cerium oxide and zirconium oxide, wherein the cerium oxide is present in an amount from about 58% to about 80% by weight of mixed metal oxide and the zirconium oxide is present in amount from about 42% to about 20% by weight of mixed metal oxide, and optionally a support dopant; and

about 0.1% to about 0.2% by weight of total catalyst of a promoter comprising alkali metals, or alkaline earth metals, or combinations thereof

the high activity water gas shift catalyst system having a conversion rate of at least 50% for reacting carbon monoxide and water into carbon dioxide and hydrogen in a water gas shift reaction over a temperature range ~~of~~ from about 300°C to about 450°C.

37. (Original) The high activity water gas shift catalyst system of claim 36 wherein the noble metal is selected from platinum, palladium, mixtures of platinum and palladium, or mixtures of platinum and iridium.

38. (Original) The high activity water gas shift catalyst system of claim 36 wherein the noble metal is present in an amount of between about 1% to about 4% by weight of total catalyst.

39. (Cancel)

40. (Previously Presented) The high activity water gas shift catalyst system of claim 36 wherein the support dopant is selected from lanthanum, praseodymium, neodymium, or combinations thereof.

41. (Previously Presented) The high activity water gas shift catalyst system of claim 36 wherein the support dopant is present in an amount of between about 1 and about 5% by weight of mixed metal oxide.

42. (Previously Presented) The high activity water gas shift catalyst system of claim 36 wherein the promoter is selected from cesium, lithium, rubidium, potassium, magnesium, strontium, barium, calcium, or combinations thereof.

43. (Cancel)

44. (Currently Amended) A high activity water gas shift catalyst system <u>for a fuel cell, in which there is a primary reactor with a reforming catalyst followed by a water gas shift converter with the high activity water gas shift catalyst system to provide a feed stream for the fuel cell, the high activity water gas shift catalyst system</u> comprising:

a noble metal; and

a mixed metal oxide support consisting essentially of cerium oxide and zirconium oxide, wherein cerium oxide is present in an amount from about 20% to less than 58% by weight of mixed metal oxide and zirconium oxide is present in amount from more than 42% to about 80% by weight of mixed metal oxide, and optionally a support dopant;

about 0.1% to about 0.2% by weight of total catalyst of a promoter comprising at least one metal selected from alkali metals, and alkaline earth metals,

the high activity water gas shift catalyst system having a conversion rate of at least 50% for reacting carbon monoxide and water into carbon dioxide and hydrogen in a water gas shift reaction over a temperature range ~~of~~ from about 300°C to about 450°C.

45. (Original) The high activity water gas shift catalyst system of claim 44 wherein the noble metal is selected from platinum, palladium, mixtures of platinum and palladium, or mixtures of platinum and iridium.

46. (Original) The high activity water gas shift catalyst system of claim 44 wherein the noble metal is present in an amount of between about 1% to about 4% by weight of total catalyst.

47. (Canceled)

48. (Previously Presented) The high activity water gas shift catalyst system of claim 44 wherein the support dopant is selected from lanthanum, praseodymium, neodymium, or combinations thereof.

49. (Previously Presented) The high activity water gas shift catalyst system of claim 44 wherein the support dopant is present in an amount of between about 1 and about 5% by weight of mixed metal oxide.

50. (Canceled)

51. (Previously Presented) The high activity water gas shift catalyst system of claim 44 wherein the promoter is selected from cesium, lithium, rubidium, potassium, magnesium, strontium, barium, calcium, or combinations thereof.

52. (Canceled)

53. (Currently Amended) A high activity water gas shift catalyst system <u>for a fuel cell, in which there is a primary reactor with a reforming catalyst followed by a water gas shift converter with the high activity water gas shift catalyst system to provide a feed stream for a fuel cell, the high activity water gas shift catalyst system</u> comprising:

a noble metal;

a mixed metal oxide support consisting essentially of cerium oxide and lanthanum oxide~~:~~, wherein cerium oxide is present in an amount from about 20% to less than 92% by weight of mixed metal oxide and lanthanum oxide is present in amount from about 80% to more than 8% by weight of mixed metal oxide, and optionally a support dopant; and

about 0.1% to about 0.5% by weight of total catalyst of a promoter comprising at least one metal selected from alkali metals, and alkaline earth metals,

the high activity water gas shift catalyst system having a conversion rate of at least 40% for carbon monoxide to carbon dioxide and hydrogen in a water gas shift reaction over a temperature range from about 400°C to about 575°C.

54. (Canceled)

55. (Original) The high activity water gas shift catalyst system of claim 53 wherein the noble metal is selected from platinum, palladium, mixtures of platinum and palladium, or mixtures of platinum and iridium.

56. (Original) The high activity water gas shift catalyst system of claim 53 wherein the noble metal is present in an amount of between about 1% to about 4% by weight of total catalyst.

57. (Original) The high activity water gas shift catalyst system of claim 53 wherein the support dopant is selected from praseodymium, neodymium, or combinations thereof.

58. (Original) The high activity water gas shift catalyst system of claim 53 wherein the support dopant is present in an amount of between about 1 and about 5% by weight of mixed metal oxide.

59. (Canceled)

60. (Previously Presented) The high activity water gas shift catalyst system of claim 53 wherein the promoter is selected from cesium, lithium, rubidium, potassium, magnesium, strontium, barium, calcium, or combinations thereof.

61. (Canceled)

62. (Previously Presented) The method of claim 1 wherein the promoter is present in an amount of about 0.1% to about 0.2%.

63. (Previously Presented) The method of claim 12 wherein the promoter is present in an amount of about 0.1% to about 0.2%.

64. (Previously Presented) The method of claim 24 wherein the promoter is present in an amount of about 0.1% to about 0.5%.